3/1/08 - 01780

Final

# Focused Feasibility Study
# for
# Site 23 - Building LP-20 Plating Shop

Naval Station Norfolk

Norfolk, Virginia

NAVFAC
Naval Facilities Engineering Command
NAVFAC MID-ATLANTIC

Prepared for

## Department of the Navy
### Naval Facilities Engineering Command
### Mid-Atlantic

Contract No. N62470-02-D-3052
CTO-0066

**March 2008**

Prepared by

CH2MHILL

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## Norfolk, Virginia

**Contract Task Order 0066**

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**Department of the Navy**
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Under the

**LANTDIV CLEAN III Program**
**Contract N62470-02-D-3052**

Prepared by

CH2MHILL

**Chantilly, Virginia**

# Executive Summary

This report presents a focused feasibility study (FFS) for Site 23, Building LP-20 Plating Shop, at Naval Station Norfolk (NSN), Norfolk, Virginia. This FFS documents the analyses used to develop remedial action alternatives for Site 23 and provides an evaluation of those alternatives. The information presented herein will be used by the Navy and regulatory agencies to select a cost-effective remedial alternative that complies with the requirements of the National Oil and Hazardous Substances Pollution National Contingency Plan (NCP).

Site 23, the former Plating Shop, is located within Building LP-20, on the west side of the building (Figure 1-2). Building LP-20 is one of many large buildings located northwest of the Chambers Field main runway in an industrial section of NSN (Figure 1-1). Building LP-20 is currently used as a motor pool and office space; however, Site 23 (the Plating Shop) is not currently in use. The site will be used in the future as a storage facility or warehouse.

The former Plating Shop contained seven process pits that extend beneath the concrete slab floor. These pits were used for cleaning, stripping, and plating engine parts. The floor of the shop and the pits were lined with corrosion resistant brick tiles. Previous investigations identified metals (cadmium, chromium, lead, and nickel) in surface soil (collected immediately beneath the concrete flooring) and PAHs and metals (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and cadmium) in subsurface soil that may pose unacceptable risks.

Groundwater beneath Building LP-20 (including the Plating Shop) is being addressed separately under the CERCLA program as part of Installation Restoration (IR) Site 20 – Building LP-20. A Remedial Investigation/Feasibility Study was completed by Baker Environmental, Inc. for Site 20 in December 1995 and an air sparge/soil vapor extraction system was installed and began operation in 1998. Currently, Site 20 is part of the Long-Term Monitoring (LTM) program at NSN.

An Engineering Evaluation/Cost Analysis (EE/CA) was prepared in 2006 to evaluate alternatives for addressing potential risks associated with site soil. The following three alternatives were compared:

- Alternative 1: No Action
- Alternative 2: Concrete Cover to Prevent Exposure to Soil
- Alternative 3: Floor Demolition, Excavation, Off-Site Disposal, and Restoration of Building

Alternative 2 was recommended and a Non-Time Critical Removal Action (NTCRA) was implemented in 2007. All debris and brick tiling located within the process pits and brick tiles covering the floor were removed and appropriately disposed. The Plating Shop pits were filled with flowable concrete fill and the pits and Plating Shop floor were covered with concrete and an additional impermeable sealant to provide protection against exposure to soil underlying the Plating Shop. Under Alternative 2, soil that was found to potentially

pose unacceptable risks to human receptors remained at the site. Consequently, this FFS focuses on evaluating remedial alternatives to prevent exposure to this remaining soil.

The site-specific Remedial Action Objective (RAO) for Site 23 is to limit use and restrict exposure to soil beneath the former process pits that poses a potential unacceptable risk to human health. Based on future use of Site 23 as an industrial site, the existing concrete cover prevents exposure to soil. Construction workers, however, could be exposed to impacted soil during excavations or other intrusive activities.

The following alternatives were developed to address this risk:

- Alternative 1 - No Action
- Alternative 2 – Land Use Controls (LUCs)

The recommended remedial alternative is Alternative 2, LUCs. This alternative achieves the RAO by limiting site access and use to prevent exposure to unacceptable risks in soil. Under this alternative, any necessary measures for protecting construction workers from exposure to soil would be addressed in a Remedial Design (RD). The recommended alternative meets the NCP evaluation criteria.

The major components of Alternative 2 include:

- Preparing a Remedial Design (RD) to outline the LUC objectives and to specify measures for implementing the LUCs,
- Installing signs at Site 23 entrances describing the site conditions and restrictions,
- Performing periodic site inspections and associated reporting to ensure continued effectiveness of the NTCRA, and
- Conducting five year site reviews and preparing reports as required under CERCLA to evaluate the continuing effectiveness, protectiveness, and need for LUCs.

The recommended alternative will be presented in a Proposed Remedial Action Plan (PRAP) that will be submitted for public comment. Public comments will be reviewed and a remedy will be selected and formally documented in a Record of Decision (ROD).

# Contents

**Figures (located at the end of each section)**



**Tables (located within the text)**



**Appendices**

# Acronyms and Abbreviations

| | |
|---|---|
| ARAR | Applicable or Relevant and Appropriate Requirement |
| AS/SVE | air sparge/soil vapor extraction |
| bgs | below ground surface |
| BRA | Baseline Risk Assessment |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CLEAN | Comprehensive Long-term Environmental Action Navy |
| COPC | contaminant of potential concern |
| CTO | Contract Task Order |
| CWA | Clean Water Act |
| 1,2-DCE | 1,2-dichloroethene |
| EE/CA | Engineering Evaluation/Cost Analysis |
| FFS | Focused Feasibility Study |
| GRA | General Response Action |
| HHRA | Human Health Risk Assessment |
| IR | Installation Restoration |
| IWS | Industrial Waste Sewer |
| LTM | Long Term Monitoring |
| LUC | Land Use Control |
| NAVFAC | Naval Facilities Engineering Command |
| NCP | National Oil and Hazardous Substances Pollution National Contingency Plan |
| NPW | Net Present Worth |
| NSN | Naval Station Norfolk |
| NTCRA | Non-Time Critical Removal Action |
| OMB | Office of Management and Budget |
| O&M | Operations & Maintenance |
| PAH | Polycyclic Aromatic Hydrocarbon |
| POTW | publicly owned treatment works |
| PRAP | Proposed Remedial Action Plan |
| PRI | pre-remedial investigation |

| | |
|---|---|
| RAO | Remedial Action Objective |
| RBC | risk-based concentration |
| RCRA | Resource Conservation and Recovery Act |
| RD | Remedial Design |
| RI | Remedial Investigation |
| ROD | Record of Decision |
| SARA | Superfund Amendments and Reauthorization Act |
| SDWA | Safe Drinking Water Act |
| SI | Site Investigation |
| SMCL | Secondary Maximum Contaminant Level |
| SVOC | Semi-volatile Organic Compound |
| TBC | to be considered |
| TCE | trichloroethylene |
| USEPA | United States Environmental Protection Agency |
| UST | underground storage tank |
| VC | vinyl chloride |
| VDEQ | Virginia Department of Environmental Quality |
| VOC | Volatile Organic Compound |

SECTION 1

# Introduction

This report presents the results of a focused feasibility study (FFS) for Site 23, Building LP-20 Plating Shop, at Naval Station Norfolk (NSN), Norfolk, Virginia. CH2M HILL prepared this FFS report for Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic Division, under the Comprehensive Long-Term Environmental Action Navy (CLEAN) III Contract N62470-02-D-3052, Contract Task Order (CTO) 0066. This report was submitted to the United States Environmental Protection Agency (USEPA) and the Virginia Department of Environmental Quality (VDEQ), participants in the NSN Tier I Partnering Team, for review and comment. The FFS for Site 23 addressed impacts to soil beneath the concrete floor of the former Plating Shop within Building LP-20.

## 1.1 Objective and Approach

The FFS for Site 23 was prepared in accordance with the National Oil and Hazardous Substances Pollution National Contingency Plan (NCP); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA); and the 1988 USEPA guidance titled *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988).

The remedial alternatives described in this FFS report are consistent with the requirements of the NCP and are designed to reduce potential future risks to human health from constituents present in soil at Site 23. The FFS consisted of the following tasks:

- Developing remedial action objectives (RAOs)
- Identifying applicable or relevant and appropriate requirements (ARARs)
- Screening of potentially applicable remedial technologies based on effectiveness, implementability, and cost criteria
- Assembling remedial alternatives that, to the maximum extent practicable, provide permanent solutions and use alternative technologies
- Analyzing the remedial alternatives in detail using the nine NCP evaluation criteria

Following completion of the FFS, a recommended alternative that best satisfies the RAOs will be presented in a Proposed Remedial Action Plan (PRAP) that will be submitted for public comment. The resulting comments will be reviewed and a remedy will be selected and formally documented in a Record of Decision (ROD).

The results of the FFS are presented in the following sections:

- Section 1.0 - Introduction
- Section 2.0 – Development and Screening of Alternatives

- Section 3.0 – Detailed Analysis of Alternatives
- Section 4.0 - Comparative Analysis of Alternatives
- Section 5.0 - Recommended Alternative

References are provided in Section 6.0. Figures referenced within the text are provided at the end of each section. Appendices are provided at the end of the report.

## 1.2 Facility Description

NSN is the largest naval base in the United States. It is comprised of 4,631 acres of land (A.T. Kearny, March 1992) situated in the northwest portion of the City of Norfolk, Virginia (Figure 1-1). NSN is bounded on the north by Willoughby Bay, on the west by the confluence of the Elizabeth and James Rivers, and on the south and east by the City of Norfolk. A portion of the NSN eastern boundary is formed by Mason Creek.

NSN includes approximately 4,000 buildings, 20 piers, and an airfield. The western portion of NSN is a developed waterfront area containing the piers and facilities for loading, unloading, and servicing naval vessels. Land use in the surrounding area is commercial, industrial, and residential. The waterfront area south of NSN provides shipping facilities for several large industries. A network of rail lines is located in the area to service nearby industries. Residential areas surround NSN to the south and east. Willoughby Spit, a residential area located northeast of the NSN, is also used for recreational activities.

## 1.3 Site Description

### 1.3.1 Site History

Site 23 is located inside Building LP-20 (Figure 1-2). Building LP-20 is one of many large buildings located northwest of the Chambers Field main runway. Currently, the building is used as a motor pool and office space. The former Plating Shop area within the building, designated Site 23 is currently not in use. In the past, a portion of the building was used for aircraft engine overhaul and maintenance. It is anticipated that use of the site will continue to be industrial. No residential development is planned or expected for Building LP-20 or the immediate surrounding area.

Previous activities at the building included painting, x-ray facilities, cleaning and blasting, and a metal-plating operation. Rinse waters generated from these activities were transferred to the industrial wastewater treatment plant via underground piping. In addition, a large fuel storage area, known as LP fuel farm, is located south of the building. An underground pipeline extends from the Fuel Farm to Buildings LP-78 and LP-176 which are located east of the site. Between the 1940s and 1990s, numerous spills or releases of wastewater and petroleum have been documented. Significant releases were associated with damage to underground wastewater lines during construction activities, and leakage of the underground petroleum pipeline (Baker Environmental, Inc., December 1995).

Groundwater impacts from Site 23-related activities are being addressed as part of the Installation Restoration (IR) Site 20 - Building LP-20 site under the CERCLA program. Therefore, this FFS focused on addressing impacted soil at Site 23. Additional information

on the Site 20 groundwater conditions is provided in Section 1.2 of the 2006 Site Investigation (SI) report (CH2M HILL, April 2006).

Site 23, the Plating Shop, is located on the west side of Building LP-20 (Figure 1-2). The Plating Shop occupies approximately 9,500 square feet of the building, a little less than a quarter of the total area of LP-20. The Plating Shop, which is currently not in use, contained seven process pits that extended beneath the concrete slab floor and were used for cleaning, stripping, and plating engine parts. The floor of the shop and the pits were lined with corrosion resistant brick tiles.

Following a 1989 site visit by the VDEQ, an enforcement order for the Plating Shop at Building LP-20 was issued in December 1990. Under the Resource Conservation and Recovery Act (RCRA) program, a Clean Closure Plan and Contingency Plan were completed in 1993 and approved by VDEQ in September 1994. The Navy requested a modification of the plans in order to conduct a risk-based closure. Multiple phases of investigation were conducted for partial implementation of the Risk-Based Closure Plan (Versar, December 1997). Although final closure was not achieved under the RCRA program, partial closure that included the removal of the process tanks and equipment located in pits and removal of the piping for decontamination or disposal as hazardous waste did occur. In September 2000, a revised Clean Closure Plan (Versar, September 2000) was submitted to VDEQ that consisted of the general cleanup and decontamination of the Plating Shop and removal of the top 3 feet of soil beneath the Plating Shop. No additional activities were performed under the RCRA program following the submittal of the revised Clean Closure Plan and the Contingent Closure Plan by Versar, Inc. in September 2000. In July of 2003 the site was moved into the CERCLA program and designated as Site 23 - Building LP-20 Plating Shop.

A SI was conducted in 2004 under the CERCLA program. Additional surface and subsurface soil samples were collected in three different areas of the Plating Shop to fill spatial data gaps from previous sampling and delineate soil contamination within the Plating Shop area outside of the pits. The SI report was finalized in April 2006 (CH2M HILL, April 2006).

An Engineering Evaluation/Cost Analysis (EE/CA) finalized in December 2006 (CH2M HILL, December 2006) and an Action Memorandum prepared in 2007 (CH2M HILL, 2007) documented evaluation of a non-time critical removal action (NTCRA) to mitigate potential human health risk associated with contaminated soil beneath the former process pits. A streamlined human health risk assessment was also completed as part of the EE/CA. The results of the risk assessment are summarized in Section 1.7. The NTCRA that was performed in 2007 included removing brick tiling from the process pits and shop floor, backfilling the process pits and interconnected conduits with flowable concrete fill, and installing a 6 inch concrete cover with an industrial floor sealant to prevent potential exposure to underlying impacted soil (Figure 1-3). The construction activities are documented in the *Final Completion Report, Site 23, LP-20 Plating Shop, Naval Station Norfolk, Norfolk, Virginia* Construction (Shaw, 2007).

### 1.3.2 Site Geology and Hydrogeology

Geology at Site 23 was characterized from boring logs collected during the 1994 SI activities. These boring logs, which extended to a maximum depth of nine feet below ground surface

(bgs), indicate that the subsurface soil is generally characterized by fine grained sands and clayey silt/silty clay. The soil beneath the site consists of some fill material. Debris (coal fragments, ash, gravel, and wood) was observed at two boring locations (DS05 and DS23) (Figure 1-4). In addition, shell fragments were observed in soil at the majority of the boring locations and may indicate the use of dredge spoil as fill material.

Groundwater at the site is generally encountered at a depth of approximately 6 feet bgs. A groundwater evaluation was not conducted as part of the Site 23 SI (CH2M HILL, April 2006); however, the general groundwater flow direction of the area was characterized during the Site 20 Remedial Investigation (Baker Environmental, Inc., September 1996). The groundwater flow across the site trends in a northeasterly direction. Groundwater at this site is not utilized as a potable water supply.

## 1.4 Previous Investigations

Site 23 (Building LP-20 Plating Shop) is located within the boundary of Site 20 (the Building LP-20 site) therefore; the results of previous investigations at Site 20 were used in part to evaluate the contamination within Site 23. This section summarizes the pre-remedial investigation (PRI) and RI activities conducted in the Site 20 LP area as well as the RCRA and CERCLA investigations conducted at Site 23.

Groundwater at Site 23 is being addressed through the groundwater remedy for Site 20 as part of the Long-Term Monitoring (LTM) program at NSN. An air sparge/soil vapor extraction (AS/SVE) system was installed and began operation in 1998 as part of the remedial action at Site 20. As previously noted this FFS addresses soil only and does not address groundwater at Site 23. More detailed information on previous investigations is available in Section 1.2 of the Site 23 SI report (CH2M HILL, April 2006).

### 1.4.1 Site 20: Pre-Remedial Investigations (1986 – 1994)

Eleven separate PRIs were carried out between September 1986 and May 1994 in the Site 20 LP area. The investigations were performed primarily to characterize subsurface soil and groundwater contamination suspected to originate from the LP Fuel Farm (south of Building LP-20), past industrial activity in the LP-20 area, and underground storage tanks (USTs) in the area. The investigation results showed widespread chlorinated solvent and petroleum contamination in the vicinity of Building LP-20. Additional information on each of these PRIs is detailed in the *Final RI and Baseline Risk Assessment for Building LP-20 Site* (Baker Environmental, Inc., September 1996).

### 1.4.2 Site 20: Remedial Investigation (1994 – 1995)

The RI consisted of five separate phases of investigations conducted in the Building LP-20 area between December 1994 and October 1995 (Baker Environmental, Inc., December 1995). Volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals were detected in soil (surface and subsurface) and groundwater (shallow and deep aquifer) samples with a number of contaminants in both soil and groundwater media exceeding applicable standards and guidelines. Site contamination was attributed, in part, to past storage and disposal activities for chemical solvents used for cleaning, painting, and metal plating operations in Building LP-20. Additional sources of contamination were activities

related to past storage and transfer of petroleum products and releases of waste fluids through breaks in the Industrial Waste Sewer (IWS). The RI and Baseline Risk Assessment (BRA) (Baker, December 1995) provide the complete risk assessment evaluation for Site 20.

### 1.4.3 Site 23 LP-20 Plating Shop: RCRA Investigation (1996 – 1997)

Three phases of RCRA Investigations were performed at Site 23 (the Building LP-20 Plating Shop). Phase I of the field investigation was conducted in February 1996 as detailed in the Clean Closure Plan (Norfolk Naval Base, February 1993). During this phase, 26 shallow soil borings were sampled within the Plating Shop and former process units. Two deep soil samples were also collected along the IWS running through the Plating Shop. Eight soil samples were collected from background locations in the vicinity of Building LP-18. Five concrete floor samples within the Plating Shop and background concrete samples (from areas with little to no industrial activity) were collected. During Phase II in October 1996 thirteen additional borings and 21 additional subsurface soil samples were collected to provide further horizontal and vertical delineation of contamination. The Phase II data was incorporated into a Revised Closure Report, submitted to VDEQ (O'Brien and Gere, December 1997). Based on VDEQ's comments, three additional background soil samples were collected in December 1997 as Phase III of the investigation.

During the three phases of investigations, eleven VOCs (chloroform, trichloroethylene [TCE], 1,2,-dichloroethene [1,2-DCE], methylene chloride, 1,1-dichloroethane, ethylbenzene, toluene, vinyl chloride [VC], xylene, trichlorofluoromethane, and cis-1,2 dichloroethene) and cyanide were detected in shallow soil samples (collected from a depth of 0 to 6 inches) with the highest concentrations generally observed in the vicinity of the former process areas.

In the deep soil borings (collected from a depth greater than 6 inches), three VOCs (1,2-DCE, TCE, and VC) were detected at low levels. Nine of the eleven deep soil locations indicated TCE and cyanide concentrations less than the corresponding 0 to 6 inch sampling interval. Concentrations of metals collected from the 12 to 18 inch interval were generally lower than samples collected from the 0 to 6 inch interval. However, chromium and lead concentrations increased with depth at two soil sample locations.

VOCs were most prevalent in concrete samples collected in the vicinity of the former chrome strip line while metals and cyanide were most prevalent in the vicinity of the cadmium plating unit. The RCRA Closure Report (O'Brien and Gere, December 1997) provides an in depth discussion of the risk assessment evaluation for the Building LP-20 site area.

### 1.4.4 Site 23 Building LP-20 Plating Shop: Site Investigation (2004 – 2006)

A total of 55 surface and subsurface soil samples were collected in 2004 at 26 locations in three different areas of the plating shop; the hotspots, metal plating/process pits, and outside the process pits. The number of samples and sample placement were designed to fill spatial data gaps from previous sampling and delineate soil contamination within the plating shop area outside of the pits. Polycyclic aromatic hydrocarbons (PAHs) and metals were detected above residential and industrial risk-based concentrations (RBCs) in the surface and subsurface soil. One VOC (VC) was also detected above the residential RBC at

one location in the subsurface soil. Section 1.6 below presents a more detailed discussion of the SI soil sampling results.

### 1.4.5 Site 23 Building LP-20 Plating Shop: Engineering Evaluation/Cost Analysis (2006)

Based on the SI results and recommendations by the NSN Tier I Partnering Team, an EE/CA was prepared in accordance with CERCLA to evaluate alternatives for addressing potential risks posed by site soil (CH2M HILL, December 2006). A NTCRA was evaluated to address soil in the process pits beneath the floor of Building LP-20 which are impacted by PAHs, arsenic, cadmium, chromium, lead, and nickel from past metal plating activities (Figure 1-3). The main objective of the NTCRA for Site 23 was to prevent human exposure to contaminants in the soil beneath the former process pits in the Building LP-20 Plating shop. The three alternatives evaluated were:

- Alternative 1: No Action
- Alternative 2: Concrete Cover to Prevent Exposure to Soil
- Alternative 3: Floor Demolition, Excavation, Off-Site Disposal, and Restoration of Building

The EE/CA concluded that both Alternatives 2 and 3 would meet the EE/CA objectives; however, Alternative 3 would be extremely costly and difficult to implement when compared with Alternative 2. Therefore, Alternative 2 was the recommended alternative. The EE/CA was made available for public review and comment and the NTCRA was implemented in 2007 as described in Section 1.5 below. Under Alternative 2, soil that was found to potentially pose unacceptable risks to human receptors remained at the site. Therefore, this FFS addresses remedial actions necessary to prevent exposure to unacceptable risks in soil remaining at site.

## 1.5 Previous Removal Actions

Under the RCRA program, a partial closure of the site was performed that included the removal of the process tanks and equipment located in the pits and removal of the piping for decontamination or disposal (Versar, December 1997). In 2007, the NTCRA recommended in the 2006 EE/CA was implemented (Figure 1-3) (CH2M HILL, December 2006). All debris and brick tiling located within the process pits and brick tiles covering the floor were removed and appropriately disposed. The Plating Shop pits and interconnected conduits were filled with flowable concrete fill, and concrete cover with an industrial floor sealant was constructed to prevent potential exposure to underlying impacted soil. The construction activities are documented in the *Final Completion Report, Site 23, LP-20 Plating Shop, Naval Station Norfolk, Norfolk, Virginia* Construction (Shaw, 2007).

## 1.6 Summary of Most Recent Soil Sampling Results

Previous investigations of Site 23 soil have identified metals, PAHs, and VOCs at concentrations exceeding human health RBCs. The following paragraphs discuss the analytical results of the most recent soil investigation performed in 2004 during the SI.

(CH2M HILL, April 2006). Results from other historic investigations are provided in Section 1.2 of the SI.

### Surface Soil

Surface soil samples were collected directly below the concrete slab during the SI field investigations and were analyzed for VOCs, SVOCs, and metals. The constituents detected in the surface soil samples that exceeded the industrial or residential RBCs are shown on Figure 1-4.

No VOCs were detected above USEPA Region III residential or industrial soil RBCs (USEPA, April 2006). Five SVOCs, all PAHs, exceeded the residential soil RBCs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene). The distribution of SVOCs indicates that these constituents appear to be limited to isolated areas in the northern (DS26 and DS25), northwestern (DS23, DS19, and DS20), and western (DS11, DS10, and DS07) portions of the site (Figure 1-4). The highest concentrations of SVOCs, with some exceedances of the industrial soil RBCs, occurred at locations DS19, DS11, and DS07.

A total of nine metals exceeded the residential soil RBCs in the surface soil (antimony, arsenic, cadmium, chromium, iron, lead, nickel, silver, and thallium). Exceedances of the residential soil RBCs for cadmium, chromium, iron, and lead were observed in the majority of the samples in the eastern half of the site. Scattered residential soil RBC exceedances for chromium and iron were observed in the western half of the site. Arsenic exceeded the industrial and residential soil RBCs in all of the surface soil samples. The highest concentrations of metals were observed in the southern portion of the site with industrial RBC exceedances for chromium, cadmium, and nickel observed at locations DS01, DS02, DS03, and DS05 (Figure 1-4). Exceedances of the lead screening value were also observed at locations in the eastern (DS17 and DS18) and southern (DS03) portions of the site. Hexavalent chromium exceeded the residential soil RBC at location DS05. Thallium exceeded the residential soil RBC at location DS02.

A comparison of the detected constituents in surface soil to the background levels (CH2M HILL, September 2000) showed that the majority of the arsenic concentrations (18 out of a total of 26) were below the background levels. In addition, some of the benzo(a)pyrene, iron, and the thallium RBC exceedances were below the background levels.

### Subsurface Soil

Subsurface soil samples were collected from depths of 1 to 8 feet below the concrete slab. Samples were collected from 1-foot intervals and denoted in the sample ID with the maximum depth of the interval (DS01-05 = 4-5 foot interval). Subsurface soil samples collected during the investigation were analyzed for VOCs, SVOCs, and metals. The constituents detected in the subsurface soil samples that exceeded either residential or industrial soil RBCs are shown in Figure 1-5.

Vinyl chloride (VC), at sample location DS24, was the only VOC that was detected at a concentration that exceeded the residential soil RBC. Eight SVOCs exceeded the residential soil RBCs in subsurface soil (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-

cd)pyrene). The distribution of SVOCs indicates that these constituents appear to be limited to isolated areas in the northwest (DS23 and DS19), northeast (DS25), and southwest (DS05, DS06, and DS07) portions of the site (Figure 1-5). The highest concentrations of SVOCs, with some exceedances of the industrial soil RBCs, occurred at locations DS19, DS23, and DS06.

Seven metals exceeded the residential soil RBCs in the subsurface soil (arsenic, cadmium, chromium, iron, lead, nickel, and silver). Exceedances of the residential soil RBCs for cadmium, chromium, and iron were observed across the site. Scattered residential soil RBC exceedances for silver and nickel were observed. Arsenic exceeded the industrial and residential soil RBCs in all of the subsurface soil samples. The highest concentrations of metals were observed in the southern portion of the site with industrial soil RBC exceedances for chromium (DS05) and cadmium (DS06). Exceedances of the lead screening value were observed at one location (DS02) in the southern portion of the site.

## 1.7 Summary of Risk Assessment Results

A streamlined risk evaluation was performed as part of the EE/CA in accordance with USEPA's guidance document on conducting NTCRAs (USEPA, August 1993). Detailed information on the risk assessment methodology and results is provided in Section 2.5 of the Site 23 EE/CA (CH2M HILL, December 2006). The risk evaluation identified contaminants of potential concern (COPCs) at the site and identified potential future human exposures that should be prevented.

Site 23 is not in use so there are no current receptors. The site is in an industrial building in an industrial section of NSN; therefore, the most likely human receptors are future construction workers and potential future industrial workers. The site will be used in the future as a storage facility or warehouse.

The risk assessment, which was performed prior to and in preparation for the NTCRA, identified the most likely future exposure pathways as exposure to soil through direct contact and through inhalation of fugitive dust or volatile emissions while working at the site. The pathways were identified assuming that no remediation activities would occur. The industrial pathway is no longer complete following completion of the NTCRA to construct a concrete cover in 2007. The only potential future exposure pathway is to construction workers performing intrusive activities (such as excavations) extending below the Plating Shop floor. As previously discussed, groundwater was not evaluated as part of the streamlined risk assessment for Site 23 as it had been evaluated during the Site 20 evaluation. Surface water runoff from the site is unlikely since the site is located inside a building, which eliminates precipitation onto the site, and the possibility of water that may collect on the site (groundwater infiltration) from flowing off-site. However, groundwater in contact with the soil may potentially serve as a transport mechanism and carry contaminants downgradient from the site.

The screening of the Site 23 surface and subsurface soil data resulted in a number of COPCs which indicated a potential for unacceptable human health risks associated with exposure to the surface and subsurface soil at Site 23. Although concentrations of constituents in surface and subsurface soil were above both residential and industrial RBCs, the assessment

focused on evaluating potential risks associated with industrial site use since it is extremely unlikely that the site will be developed for residential use in the near future.

For surface soil, the COPCs retained were inorganic constituents including cadmium, chromium, lead, and nickel. The COPCs retained for the subsurface soil were PAHs and metals including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and cadmium.

Results of the streamlined risk assessment indicated that removal or remediation measures are needed to limit use and restrict exposure to soil beneath the former process pits. Based on future use of Site 23 as an industrial site, the existing concrete cover prevents an exposure to soil. Construction workers, however, could be exposed to impacted soil during excavations or other intrusive activities. The NTCRA performed in 2007 in combination with the additional remedial measures evaluated in this FFS will prevent future exposure to the unacceptable risks posed by soil remaining beneath the concrete cover at Site 23.

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Site 23 - Building LP-20 Plating Shop

N

0 2000 4000 Feet

Figure 1-1
Installation Location Map
Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

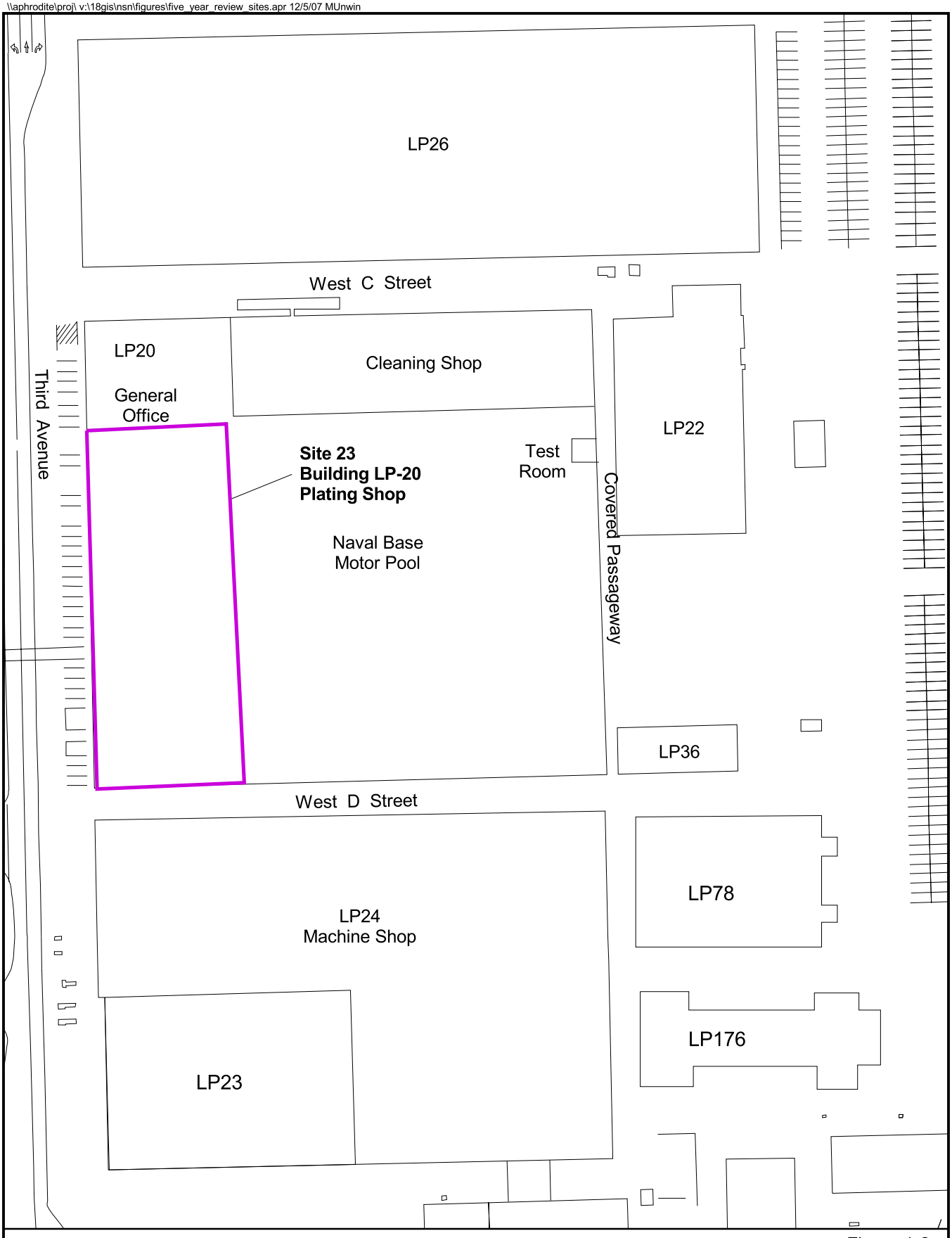


Figure 1-2
Site Map
Site 23 - Building LP-20 Plating Shop
Naval Station Norfolk
Norfolk, Virginia

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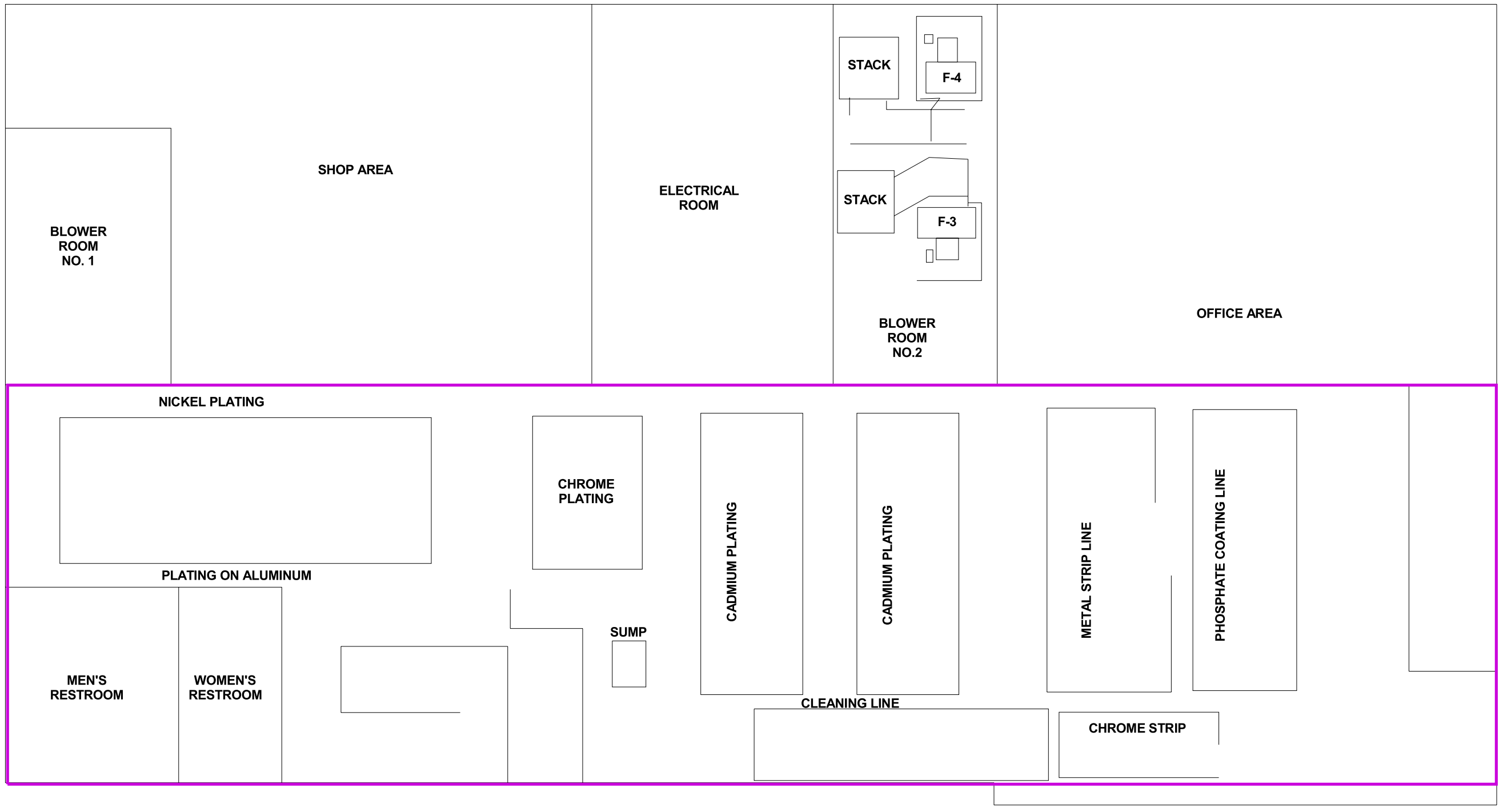


**LEGEND**

Interim Removal Action Area

N

0 10 20 Feet

Figure 1-3
Limits of Non-Time Critical Removal Action
Naval Station Norfolk
Norfolk, Virginia

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| NBS23-DS24 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 26.6 |

| NBS23-DS26 | Conc. |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 310 J |
| Dibenz(a,h)anthracene | 99 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 11.2 |

| NBS23-DS21 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 21.5 |
| Iron | 30,700 |

| NBS23-DS22 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 14.6 |

| NBS23-DS25 | Conc. |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 110 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 16.7 |

| NBS23-DS20 | Conc. |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 320 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 9.8 |

| NBS23-DS16 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 36.8 L |
| Iron | 75,200 J |

| NBS23-DS19 | Conc. |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)anthracene | 2,600 |
| Benzo(a)pyrene | 2,000 |
| Benzo(b)fluoranthene | 2,600 |
| Dibenz(a,h)anthracene | 120 J |
| Indeno(1,2,3-cd)pyrene | 1,300 |
| **Total Metals (MG/KG)** | |
| Arsenic | 6.3 |

| NBS23-DS23 | Conc. |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 240 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 6.7 L |

| NBS23-DS18 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 8.7 |
| Cadmium | 338 L |
| Chromium (total) | 576 L |
| Lead | 582 J |

| NBS23-DS15 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 9.8 |

| NBS23-DS17 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 13.5 K |
| Cadmium | 572 |
| Chromium (total) | 1,260 |
| Iron | 26,000 J |
| Lead | 610 K |

| NBS23-DS14 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 10.5 |
| Chromium (total) | 850 |

| NBS23-DS13 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 12.6 |

| NBS23-DS11 | Conc. |
|---|---|
| **SVOC (UG/KG)** | |
| Benzo(a)anthracene | 4,500 |
| Benzo(a)pyrene | 3,800 |
| Benzo(b)fluoranthene | 6,300 |
| Dibenz(a,h)anthracene | 870 |
| Indeno(1,2,3-cd)pyrene | 3,600 |
| **Total Metals (MG/KG)** | |
| Arsenic | 10.2 J |
| Chromium (total) | 413 |

| NBS23-DS10 | Conc. |
|---|---|
| **SVOC (UG/KG)** | |
| Benzo(a)pyrene | 140 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 15.6 L |
| Iron | 25,800 J |

| NBS23-DS12 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 17 L |
| Cadmium | 719 K |
| Chromium (total) | 351 K |
| Iron | 23,500 J |

| NBS23-DS09 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 13.6 K |

| NBS23-DS08 | Conc. |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 113 L |
| Chromium (total) | 1,390 K |
| Iron | 61,000 J |

| NBS23-DS04 | Conc. |
|---|---|
| **Total Metals (mg/kg)** | |
| Arsenic | 9.5 J |

| NBS23-DS06 | Conc. |
|---|---|
| **Total Metals (mg/kg)** | |
| Arsenic | 9.9 J |

| NBS23-DS01 | Conc. |
|---|---|
| **Total Metals (mg/kg)** | |
| Arsenic | 8 J |

| NBS23-DS07 | Conc. |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)anthracene | 15,000 |
| Benzo(a)pyrene | 11,000 |
| Benzo(b)fluoranthene | 15,000 |
| Dibenz(a,h)anthracene | 1,800 |
| Indeno(1,2,3-cd)pyrene | 6,800 |
| **Total Metals (MG/KG)** | |
| Arsenic | 10.8 |

| NBS23-DS05 | Conc. |
|---|---|
| **Total Metals (mg/kg)** | |
| Antimony | 42.8 L |
| Arsenic | 22.4 J |
| Cadmium | 2,620 J |
| Chromium (total) | 14,600 |
| Chromium (hexavalent) | 310 K |
| Iron | 43,700 J |
| Nickel | 20,100 L |

| NBS23-DS02 | Conc. |
|---|---|
| **Total Metals (mg/kg)** | |
| Antimony | 57.2 |
| Arsenic | 8.3 J |
| Chromium (total) | 28,600 |
| Iron | 37,300 J |
| Lead | 1,130 K |
| Nickel | 14,400 L |
| Silver | 839 J |
| Thallium | 8.6 |

| NBS23-DS03 | Conc. |
|---|---|
| **Total Metals (mg/kg)** | |
| Antimony | 32.1 L |
| Arsenic | 11 J |
| Cadmium | 336 J |
| Chromium (total) | 10,900 |
| Iron | 26,600 J |
| Lead | 1,700 K |
| Nickel | 5,520 L |
| Silver | 736 J |

| Chemical Name | Screening Criteria RBC-Soil Industrial | RBC-Soil Residential |
|---|---|---|
| **SVOCs (UG/KG)** | | |
| Benzo(a)anthracene | 3,900 | 870 |
| Benzo(a)pyrene | 390 | 87 |
| Benzo(b)fluoranthene | 3,900 | 870 |
| Dibenz(a,h)anthracene | 390 | 87 |
| Indeno(1,2,3-cd)pyrene | 3,900 | 870 |
| **Total Metals (MG/KG)** | | |
| Antimony | 410 | 31 |
| Arsenic | 1.9 | 0.43 |
| Cadmium | 1,000 | 78 |
| Chromium (total) | 3,100 | 230 |
| Chromium (hexavalent) | 3,100 | 230 |
| Iron | 310,000 | 23,000 |
| Lead | 400 | 400 |
| Nickel | 20,000 | 1,600 |
| Silver | 5,100 | 390 |
| Thallium | 72 | 5.5 |

West C Street

LP20

Cleaning Shop

General Office

Third Avenue

Naval Base Motor Pool

West D Street

LP24
Machine Shop

**Legend**

- Surface Soil Sample Locations
- Site Boundary

Notes:
J = value is estimated
L = value may be biased low
K = value may be biased high
U = not detected

All constituents that appear on the figure exceeded the residential RBC screening value.

Exceeds Industrial RBC

N

0 50 100 Feet

Figure 1-4
Surface Soil Exceedances of Screening Criteria
Site 23 - Building LP-20 Plating Shop
Naval Station Norfolk
Norfolk, Virginia

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| NBS23-DS19 | DS19-02 |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)anthracene | 310,000 |
| Benzo(a)pyrene | 250,000 |
| Benzo(b)fluoranthene | 300,000 |
| Benzo(k)fluoranthene | 120,000 |
| Carbazole | 55,000 |
| Chrysene | 270,000 |
| Dibenz(a,h)anthracene | 14,000 J |
| Indeno(1,2,3-cd)pyrene | 140,000 |
| **Total Metals (MG/KG)** | |
| Arsenic | 12 |
| Chromium (total) | 406 L |

| NBS23-DS23 | DS23-03 | DS23-06 |
|---|---|---|
| **SVOCs (ug/kg)** | **Conc.** | **Conc.** |
| Benzo(a)pyrene | 450 | NE |
| Dibenz(a,h)anthracene | 110 J | NE |
| **Total Metals (MG/KG)** | | |
| Arsenic | 17.3 | 35.7 L |
| Chromium (total) | 296 | NE |
| Iron | NE | 72,000 |

| NBS23-DS24 | DS24-03 |
|---|---|
| **VOCs (ug/kg)** | |
| Vinyl Chloride | 110 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 36.9 |
| Iron | 73,200 |

| NBS23-DS25 | DS25-03 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 33.7 L |
| Iron | 66,400 |

| NBS23-DS16 | DS16-02 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 19.7 L |
| Cadmium | 90.4 K |
| Chromium (total) | 351 K |

| NBS23-DS22 | DS22-03 |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 260 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 11.3 |

| NBS23-DS15 | DS15-02 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 6.3 |

| NBS23-DS21 | DS21-02 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 13.3 |
| Iron | 36,000 |

| NBS23-DS14 | DS14-02 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 29.6 L |
| Cadmium | 235 K |
| Chromium (total) | 1,900 K |
| Iron | 57,400 J |
| Silver | 468 K |

| NBS23-DS20 | DS20-03 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 24.4 |

| NBS23-DS18 | DS18-03 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 29.8 |
| Iron | 49,900 |

| NBS23-DS10 | DS10-03 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 12.5 J |
| Chromium (total) | 400 |

| NBS23-DS17 | DS17-03 | DS17-04 |
|---|---|---|
| **Total Metals (MG/KG)** | **Conc.** | **Conc.** |
| Arsenic | 21 K | 14.1 K |
| Cadmium | 112 | NE |
| Iron | 45,200 J | 34,500 J |

| NBS23-DS11 | DS11-03 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 32.5 |
| Chromium (total) | 303 |
| Iron | 51,200 J |
| Silver | 625 |

| NBS23-DS12 | DS12-02 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 11.9 L |
| Cadmium | 219 K |
| Chromium (total) | 274 K |

| NBS23-DS02 | DS02-05 | DS02-08 |
|---|---|---|
| **Total Metals (MG/KG)** | | |
| Arsenic | 8.8 J | 7.3 J |
| Chromium (total) | 1,280 | NE |
| Lead | 544 K | NE |
| Nickel | 17,600 L | NE |

| NBS23-DS07 | DS07-02 |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 270 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 2.9 |
| Chromium (total) | 290 L |

| NBS23-DS08 | DS08-05 |
|---|---|
| **Total Metals (MG/KG)** | |
| Arsenic | 7.8 J |
| Iron | 24,100 J |

| NBS23-DS05 | DS05-02 |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 130 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 19.6 L |
| Cadmium | 1,500 K |
| Chromium (total) | 2,880 K |
| Iron | 23,700 J |
| Nickel | 10,600 J |

| NBS23-DS06 | DS06-02 |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)anthracene | 1,100 |
| Benzo(a)pyrene | 1,100 |
| Benzo(b)fluoranthene | 2,000 |
| Dibenz(a,h)anthracene | 280 J |
| Indeno(1,2,3-cd)pyrene | 1,100 |
| **Total Metals (MG/KG)** | |
| Arsenic | 5.5 J |
| Chromium (total) | 3,410 |
| Silver | 567 J |

| NBS23-DS04 | DS04-03 |
|---|---|
| **SVOCs (ug/kg)** | |
| Benzo(a)pyrene | 130 J |
| **Total Metals (MG/KG)** | |
| Arsenic | 18 L |
| Iron | 24,000 J |

| NBS23-DS03 | DS03-03 | DS03-05 |
|---|---|---|
| **Total Metals (MG/KG)** | | |
| Arsenic | 15.1 L | 33.3 L |
| Cadmium | 473 K | NE |
| Chromium (total) | 1,110 K | NE |
| Iron | NE | 82,900 J |
| Nickel | 2,420 J | NE |

| Chemical Name | Screening Criteria RBC-Soil Industrial | RBC-Soil Residential |
|---|---|---|
| **VOCs (UG/KG)** | | |
| Vinyl Chloride | 4,000 | 90 |
| **SVOCs (UG/KG)** | | |
| Benzo(a)anthracene | 3,900 | 870 |
| Benzo(a)pyrene | 390 | 87 |
| Benzo(b)fluoranthene | 3,900 | 870 |
| Benzo(k)fluoranthene | 39,000 | 8,700 |
| Carbazole | 140,000 | 32,000 |
| Chrysene | 390,000 | 87,000 |
| Dibenz(a,h)anthracene | 390 | 87 |
| Indeno(1,2,3-cd)pyrene | 3,900 | 870 |
| **Total Metals (MG/KG)** | | |
| Arsenic | 1.9 | 0.43 |
| Cadmium | 1,000 | 78 |
| Chromium (total) | 3,100 | 230 |
| Iron | 310,000 | 23,000 |
| Lead | 400 | 400 |
| Nickel | 20,000 | 1,600 |
| Silver | 5,100 | 390 |

West C Street

LP20

Cleaning Shop

General Office

Third Avenue

West D Street

LP24
Machine Shop

**Legend**

- Subsurface Soil Sample Locations
- Site Boundary

Notes:
J = value is estimated
L = value may be biased low
K = value may be biased high

All constituents that appear on the figure exceeded the residential RBC screening value

Exceeds Industrial RBC

NE - Constituent did not exceed the RBC screening values

N

0 50 100 Feet

Figure 1-5
Subsurface Soil Exceedances of Screening Criteria
Site 23 - Building LP-20 Plating Shop
Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

SECTION 2

# Development and Screening of Alternatives

This section presents general and site-specific remedial action objectives (RAOs) and evaluates applicable or relevant and appropriate requirements (ARARs) for Site 23. The remedial alternatives developed, evaluated, and described in this FFS report were selected with the objective of meeting the site-specific RAO. The alternatives must also meet the standards defined by the ARARs. If the ARARs do not cover a particular situation, remedial actions should be based on the TBC (to be considered) criteria or other guidelines.

## 2.1 General Remedial Action Objectives

General RAOs are defined by the NCP and CERCLA, as amended by SARA, which is applicable to all Superfund sites. CERCLA defines the statutory requirements for developing remedies. The NCP requires that the selected remedy meet the following objectives:

- Each remedial action selected shall be protective of human health and the environment [40 CFR 300.430 (f)(ii)(A)].
- Onsite remedial actions that are selected must attain those ARARs that are identified at the time of the Record of Decision (ROD) signature [40 CFR 300.430(f)(ii)(B)].
- Each remedial action selected shall be cost effective. A remedy shall be cost effective if its costs are proportional to its overall effectiveness [40 CFR 300.430 (f)(ii)(D)].
- Each remedial action shall use permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable [40 CFR 300.430 (f)(ii)(E)].

The statutory scope of CERCLA was amended by SARA to include the following general objectives for remedial action at all CERCLA sites:

- Remedial actions "shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and control further releases at a minimum which assures protection of human health and the environment" (Section 121(d)).
- Remedial actions "in which treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element" (Section 121(b)) are preferred. If the treatment or recovery technologies selected are not a permanent solution, an explanation must be published.
- The least-favored remedial actions are those that include "offsite transport and disposal of hazardous substances or contaminated materials without treatment where practicable treatment technologies are available" (Section 121(b)).

- The selected remedy must comply with or attain the level of any "standard, requirement, criteria, or limitation under any federal environmental law, or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility citing law that is more stringent than any Federal standard, requirement, criteria, or limitation" (Section 121(d)(2)(A)).

## 2.2 Site-Specific Remedial Action Objectives

Site-specific RAOs are established based on the nature and extent of contamination, the resources that are currently and/or potentially threatened, and the potential for human and environmental exposure (USEPA, 1988). RAOs may specify acceptable threshold contaminant levels, where applicable, for various exposure pathways. Guidance for developing RAOs is outlined in Section 300.430(e)(2) of the NCP and Section 121 of SARA.

The RAO for Site 23 is to prevent unlimited use and unrestricted exposure to soil beneath the former process pits that poses a potential unacceptable risk to human health. Based on future industrial site use, the concrete cover prevents exposure to soil. Construction workers excavating soil or performing other intrusive activities are the only potential receptors that could be exposed to soil beneath the pits

## 2.3 Applicable or Relevant and Appropriate Requirements and TBCs

Under Section 121(d)(1) of CERCLA, remedial actions must attain a degree of cleanup, which assures protection of human health and the environment. Additionally, CERCLA remedial actions that leave any hazardous substances, pollutants, or contaminants on site must meet, upon completion of the remedial action, a level or standard of control that at least attains standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are known as "ARARs." ARARs are derived from both Federal and state (Commonwealth of Virginia) laws.

Definitions of ARARs, as well as other advisories, criteria, or TBC guidance are given below:

- Applicable Requirements are cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, or contaminant, remedial action, location, or other circumstance at a CERCLA site.

- Relevant and Appropriate Requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited (appropriate) to the particular site. Requirements must be relevant and appropriate to be an ARAR of this type.

- TBCs are nonpromulgated, nonenforceable guidelines or criteria that may be useful for establishing a cleanup level or for designing the remedial action, especially when no

ARARs exist or they are not sufficiently protective. Examples of TBCs include USEPA Drinking Water Health Advisories and Secondary Maximum Contaminant Levels (SMCLs).

Section 121(d)(4) of CERCLA allows the selection of a remedial alternative that will not attain all ARARs if any of six conditions for a waiver of ARARs exist. These conditions include: 1) the remedial action is an interim measure whereby the final remedy will attain the ARAR upon completion, 2) compliance will result in greater risk to human health and the environment than other options, 3) compliance is technically impracticable, 4) an alternative remedial action will attain the equivalent of the ARAR, 5) for State requirements, the State has not consistently applied the requirement in similar circumstances, and 6) compliance with the ARAR will not provide a balance between protecting public health, welfare, and the environment at the facility with the availability of CERCLA money for response at other facilities.

Subsection 121(d) of CERCLA also requires that remedies comply with Federal and State/Commonwealth substantive requirements that qualify as ARARs. Federal, State/Commonwealth, or local permits need not be obtained for removal or remedial actions implemented on site, but their substantive requirement must be obtained. "On site" is interpreted by USEPA to include the aerial extent of contamination and all suitable areas in reasonable proximity to the contamination necessary for implementation of the response action.

There are three categories of ARARs: chemical specific, location specific, and action specific. They are based on the manner in which they are applied. Many requirements are combinations of the different ARAR categories.

An explanation of each of the ARAR categories follows.

- Location-Specific ARARs: Restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of a site. Examples of this type of ARAR include Federal and State/Commonwealth citing laws for hazardous waste facilities and sites on the National Register of Historic Places.
- Action-Specific ARARs: Refers to the requirements that set controls or restrictions on particular activities related to the management of hazardous substances, pollutants, or contaminants. Resource Conservation and Recovery Act (RCRA) regulations for closure of hazardous waste storage units, RCRA incineration standards, and pretreatment standards under the Clean Water Act (CWA) for discharges to publicly owned treatment works (POTWs) are examples of action-specific ARARs.
- Chemical-Specific ARARs: Health or risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Federal MCLs established under the Safe Drinking Water Act (SDWA) are examples of chemical-specific ARARs.

As presented in **Appendix A**, there are no applicable Federal or State ARARs for Site 23.

## 2.4 Remediation Goal

Site 23 surface and subsurface soil were evaluated for potential risks associated with industrial use. The streamlined risk assessment, summarized in Section 1.7 of this report and presented in detail in Section 2.5 of the Site 23 EE/CA (CH2M HILL, December 2006), identified COPCs that may pose unacceptable risks. Exposure to metals (cadmium, chromium, lead, and nickel) in surface soil (i.e., soil located immediately below the Plating Shop pits and floor) and exposure to PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene) and metals (arsenic and cadmium) in subsurface soil may pose unacceptable risks. Concentrations of these COPCs exceeding human health RBCs are shown in Figures 1-4 and 1-5.

During the 2007 NTCRA, a concrete cover with an industrial floor sealant was installed over the Plating Shop pits and floor to prevent contact with the underlying soil. However, impacted soil that may pose unacceptable risks remains at the site. The remedial technologies and alternatives presented in the following sections address the need to prevent use that may pose an exposure risk to COPCs in the soil that remains beneath the concrete cover at the site.

## 2.5 Development of General Response Actions

General response actions are broad classes of responses, remedies, or technologies developed to meet the site-specific RAO. After the RAO was developed, two general response actions consistent with the site-specific objective were identified, including the CERCLA requirement of no action, which will serve as a baseline for comparison. The general response actions for Site 23 are:

- No Action: No Action involves no remedial action, and is included as a baseline for comparison.
- Land Use Controls (LUCs): LUCs do not reduce toxicity, mobility or volume of contamination at the site, but reduce the potential for receptor contact with contaminated media. These may include, but are not necessarily limited to: 1) use restrictions, 2) LUCs to limit the future use of the site or activities that may occur, and 3) public education.

The general response actions 1) No Action and 2) LUCs were chosen as the remedial alternatives.

SECTION 3

# Detailed Analysis of Alternatives

This section identifies, describes, and evaluates in detail the two remedial alternatives for Site 23. The purpose of the evaluation is to assess the strengths and weaknesses of the alternatives with respect to the evaluation criteria set forth in the NCP.

## 3.1 Evaluation Criteria

The detailed analysis of alternatives was conducted in accordance with the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, 1988a) and the NCP (Part 300.430(e)), including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria were evaluated in the detailed analysis:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance (not evaluated at this time)
- Community acceptance (not evaluated at this time)

State acceptance and community acceptance criteria will be evaluated by addressing comments received after the regulatory agencies and the public have reviewed the FFS and PRAP. This evaluation will be presented in the Responsiveness Summary of the ROD.

### 3.1.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is the primary criteria that a remedial action must meet. A remedy is considered protective if it adequately eliminates, reduces, or controls all current and potential site risks posed through each exposure pathway at the site. Adequate engineering controls, LUCs, or some combination of the two, can be implemented to control exposure and thereby ensure reliable protection of human health and the environment over time. In addition, implementation of a remedy cannot result in unacceptable short-term risks or cross-media impacts on human health and the environment.

### 3.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the FFS process to ensure that they will meet all ARARs, or that there is a sound rationale for waiving an ARAR. As presented in **Appendix A**, there are no applicable Federal or State ARARs for Site 23.

### 3.1.3 Long-Term Effectiveness and Permanence

This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment over time. In evaluating alternatives for their long-term effectiveness and the degree of permanence they afford, the analysis focused on the residual risks present at the site after completion of the remedial action.

The analysis included consideration of the following:

- Degree of threat posed by the hazardous substances remaining on site
- Adequacy and reliability of any controls (e.g., engineering and LUCs) used to manage the hazardous substances remaining at the site
- Potential impacts on human health and the environment, should the remedy fail

### 3.1.4 Reduction of Toxicity, Mobility or Volume through Treatment

This criterion addresses the statutory preference for remedies that employ treatment as a principal element. The criterion ensures that the relative performance of the various treatment alternatives in reducing toxicity, mobility or volume will be assessed. Specifically, the analysis will examine the magnitude, significance and irreversibility of reductions.

### 3.1.5 Short-Term Effectiveness

This criterion examines the short-term impacts associated with implementing the alternative. Implementation may impact the neighboring community, workers, or the surrounding environment. Short-term effectiveness also includes potential threats to human health and environment associated with excavation, treatment, and transportation of hazardous substances; the potential cross-media impacts of the remedy; and the time required to achieve protection of human health and the environment.

### 3.1.6 Implementability

Implementability considerations include technical and administrative feasibility of the alternatives, as well as the availability of goods and services (including treatment, storage, or disposal capacity) associated with the alternative. Implementability considerations often affect the timing of remedial actions (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material handling steps, and the need to secure technical services). On-site activities must comply with the substantive portions of applicable permitting regulations.

### 3.1.7 Cost

Cost includes capital costs, and annual operation and maintenance (O&M) costs incurred over the life of the remedial action. The focus during the detailed analysis is on the net present worth (NPW) of these costs. Costs are used to select the most cost-effective alternative that will achieve the RAO.

In accordance with USEPA guidance (USEPA, 1988a), the cost estimates are prepared to have an accuracy in the range of –30 to +50 percent. The exact accuracy of each cost estimate depends upon the assumptions made and the availability of costing information. The

present worth costs will be calculated assuming the current discount rate established by the Office of Management and Budget (OMB). The cost estimates for Alternatives 1 and 2 are provided in **Appendix B.**

## 3.2 Detailed and Comparative Analyses of Remedial Alternatives

A description of each remedial alternative is presented in **Table 3-1**. An evaluation of the alternatives with respect to the nine NCP Criteria is presented below.

### 3.2.1 Alternative 1 – No Action

Under this alternative, no actions will be taken to prevent unrestricted use, access, or exposure to contaminated soil at Site 23. The "No Action" alternative is required by the NCP and serves as the baseline alternative. All other remedial alternatives are judged against the No Action alternative.

#### Overall Protection of Human Health and the Environment

Under Alternative 1, site use and access will not be restricted, managed, or monitored. Thereby, the potential for exposure to impacted soil remaining at the site exists. As a result, this alternative will not provide protection against potential human health risks associated with exposure to COPCs in soil.

#### Compliance with Applicable or Relevant and Appropriate Requirements

No Federal or State chemical- , location- or action-specific ARARs were identified for Site 23.

#### Long-Term Effectiveness and Permanence

Long-term risks will remain at the site under the No Action alternative as this alternative will not provide protection against potential future use and exposure to contaminated soil beneath the concrete cover.

#### Reduction of Toxicity, Mobility or Volume through Treatment

The No Action alternative does not provide physical treatment processes for toxicity, mobility, or volume reduction of contaminated media. Because there is no physical treatment process, there will be no treatment residuals. The No Action alternative does not satisfy the statutory preference for treatment.

#### Short-Term Effectiveness

There are no short-term unacceptable risks to potential receptors because the site is currently not in use.

#### Implementability

The No Action alternative is readily implementable because no construction or operation activities will be conducted. The availability of services, materials and/or technologies is not applicable to this alternative.

#### Cost

There are no capital or O&M costs associated with this alternative. Therefore, the NPW is $0.

### 3.2.2 Alternative 2 – Land Use Controls

This alternative includes the development of LUCs to prevent unlimited use and unrestricted exposure to COPCs in soil. During the NTCRA performed in 2007, debris and brick tiling was removed from the Plating Shop pits and floor. The Plating Shop pits were filled with flowable concrete fill and covered with concrete cover and an industrial floor coating to prevent contact with underlying soil. However, because contaminated soil remains in place, additional remedial actions are necessary to further restrict access and control use of the site to protect against potential future exposures. LUCs will be implemented to limit contact and thereby, exposure to ensure adequate and reliable protection of human health over time.

The site is currently not in use and industrial use (as a storage facility or warehouse) is the only anticipated future land use for Site 23. A Remedial Design (RD) for LUCs for Site 23 will be developed to include provisions that would require a reevaluation of potential risks should other land use or a No Action decision be sought for the site. LUCs will include a number of physical and legal methods used to control access and future use of the site. LUCs may include restricting or limiting excavation activities; site inspections to ensure continued effectiveness of the NTCRA; posting signs describing the site conditions or restrictions; and associated reporting. It is anticipated that the site will be evaluated not less than every 5 years under CERCLA to determine the continuing effectiveness, protectiveness and need for LUCs. The objectives of the RD for LUCs for Site 23 will be addressed in the ROD.

#### Overall Protection of Human Health and the Environment

LUCs will be necessary to prevent exposure to COPCs that remain in Site 23 soil because unacceptable risks have been identified. This alternative would meet the RAO for Site 23 by restricting land use and access to protect potential receptors, such as future construction workers performing intrusive activities in soil beneath the process pits. The RD will describe any measures necessary to protect construction workers during future excavation activities.

#### Compliance with Applicable or Relevant and Appropriate Requirements

Although the site is currently not in use, under an industrial use scenario the COPCs in soil pose unacceptable risks. Future use of this site is likely to be industrial. No future residential use of this site is expected. No Federal or State chemical-, location- or action-specific ARARs were identified.

#### Long-Term Effectiveness and Permanence

If future use of Site 23 is for industrial or commercial purposes, this alternative would be effective in preventing unacceptable risk. Any change in the use of the site from industrial land use would require reassessing human health risks and reevaluating the LUCs.

### Reduction of Toxicity, Mobility or Volume through Treatment

There will be no reduction in toxicity, mobility, or volume of contaminants as a result of LUCs because removal and/or treatment are not components of the alternative.

### Short-Term Effectiveness

There are no short-term unacceptable risks to potential receptors because the site is currently not in use.

### Implementability

As the landowner, the Navy will develop, implement, and enforce LUCs to achieve the RAO for Site 23. Implementation of the LUCs is straightforward.

### Cost

Costs for LUCs include preparation of documents to prevent unlimited use and unrestricted exposure scenarios. There would be periodic inspections estimated at $1,526 per year. In addition, 5-year statutory reviews are estimated at $7,886 per event. Assuming 30 years for the timeframe of the alternative, the NPW for 30 years of LUC implementation is estimated at $64,998 (using a 2007 discount rate of 3.0 percent per OMB Circular A-94, Appendix C, and updated January 2007). A cost estimate is presented in **Appendix B**.

TABLE 3-1
Descriptions of Alternatives
*Site 23 FFS*
*Naval Station Norfolk*
*Norfolk, Virginia*

| Alternative | Components | Details | Cost | |
|---|---|---|---|---|
| **1—No Action** | Existing Site 23 Area | Not Applicable | Capital Cost | $0 |
| | | | Annual O&M | $0 |
| | | | Present-Worth | $0 |
| | | | Time Frame >70 years | |
| **2 – Land Use Controls** | - Land Use Controls (LUCs) to cover Site 23 Area | - Sign Installation<br>- Remedial Design for LUCs<br>- Integrity Inspections<br>- Statutory remedy 5-year reviews | Capital Cost | $11,600 |
| | | | Annual O&M | $1,526 |
| | | | Net Present-Worth | $64,998 |
| | | | Time Frame 30 years | |

SECTION 4

# Comparative Analysis of Alternatives

This section presents a comparative analysis of the remedial alternatives presented for Site 23.

## 4.1 Comparison of Remedial Alternatives

The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each remedial action alternative. The NCP is the basis for the detailed comparative analysis. **Table 4-1** presents a summary of the comparative analysis.

### 4.1.1 Overall Protection of Human Health and the Environment

Alternative 1, No Action, does not reduce potential risks to human health. Alternative 2 is protective of human health and the environment. LUCs reduce potential risk to human receptors by preventing unacceptable exposure to COPCs in soil.

### 4.1.2 Compliance with ARARs

There are no applicable Federal or State ARARs for Site 23.

### 4.1.3 Long-Term Effectiveness and Permanence

Alternative 1, No Action, does not achieve long-term effectiveness and permanence. Under Alternative 2, LUCs would prevent unacceptable exposures over the long-term and achieves long-term effectiveness and permanence for this future use.

### 4.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Neither Alternative 1 (No Action) nor Alternative 2 (LUCs) will reduce toxicity, mobility or volume of the contaminants at Site 23.

### 4.1.5 Short-Term Effectiveness

Site 23 is currently not in use. As long as the site is not in use, there are no current receptors that would potentially be exposed to unacceptable risks in the short-term. As a result, both Alternatives 1 and 2 would be effective in the short-term.

### 4.1.6 Implementability

Alternative 1, No Action, would be the easiest to implement as there is no effort associated with this alternative. Alternative 2, LUCs, would require preparation of a RD report, installation of signs describing the site conditions or restrictions, periodic site inspections and associated reporting (including the Five-Year Review Report), and coordination between NAVFAC, NSN, USEPA, and VDEQ to ensure the LUCs are enforced.

### 4.1.7 Cost

In terms of net present worth (NPW), the No Action alternative has no cost. There would be minimal costs to implement Alternative 2, LUCs. These costs would be for the preparation of a RD report, installation of LUC signs, and inspections and periodic reporting (including the Five-Year Review Report) to enforce the LUCs. These costs are assumed to occur over the 30-year timeframe of the alternative. However, LUCs would be implemented indefinitely. The cost estimate for Alternative 2 (LUCs) is provided in **Appendix B**.

TABLE 4-1
Comparative Analysis of Alternatives
*Site 23 FFS*
*Naval Station Norfolk*
*Norfolk, Virginia*

| | **Alternative 1 (No Action)** | **Alternative 2 (Land Use Controls)** |
|---|---|---|
| **Overall Protection of Human Health / Environment** | Not Effective | Effective |
| **Compliance with ARARs** | No ARARs | No ARARs |
| **Long Term Effectiveness and Permanence** | Not Effective | Effective |
| **Reduction of Toxicity, Mobility, or Volume** | None | None |
| **Short Term Effectiveness** | Effective under current land use | Effective |
| **Implementability** | Feasible | Feasible |
| **Cost** | None | Low |

SECTION 5

# Recommended Alternative

The following remedial alternatives have been developed and evaluated in this FFS report:

- Alternative 1 – No Action
- Alternative 2 – LUCs

The recommended remedial alternative is Alternative 2, LUCs. This recommendation is based on a detailed evaluation of alternatives using criteria including protection of human health, long-term effectiveness and performance, reduction of toxicity, mobility and volume of contamination through treatment, short-term effectiveness, implementability, and cost.

Specifically, the FFS concluded that LUCs will effectively limit site access and use to be protective against human exposure to unacceptable risks in soil. Implementation of LUCs has minimal associated cost, is straightforward and is protective in both the short and long term, and does not violate any ARARs.

SECTION 6

# References


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Versar, September 2000. *Closure Plan for RCRA Closure of Hazardous Waste Storage Facility Building LP-20 Planting Shop, Norfolk Naval Base, Norfolk, Virginia*.

Versar, December 1997. *Risk-Based Closure Plan, Metal Plating Shop Building LP-20, Naval Base Norfolk, Virginia.*

# Figures

# Appendix A
# ARARs

*There are no applicable Federal or State ARARs for Site 23.*

# Appendix B
# Cost Estimate

## Table B-1

**Summary of Cost Estimates**
**Naval Station Norfolk - Site 23 FFS**

| Alternative | Capital Cost | Capital Cost - Range of Estimate | | O&M Cost* | O&M Cost* - Range of Estimate | | Total Net Present Worth | Total Net Present Worth - Range of Estimate | |
|---|---|---|---|---|---|---|---|---|---|
| | | -30% | +50% | | -30% | +50% | | -30% | +50% |
| 1 - No Action | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| 2 - Land Use Controls | $ 11,600 | $ 8,120 | $ 17,400 | $ 53,398 | $ 37,379 | $ 80,097 | $ 64,998 | $ 45,499 | $ 97,497 |

* Costs provided are Net Present Worth Based on 3% Discount Factor

Discount factor established per "Revisions to OMB Circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis", OSWER Directive No. 9355.3-20, June 25, 1993. Updated January 2007

**Alternative 2 - Land Use Controls**
**Cost Estimate**
Site 23
NSN, Norfolk, Virginia

**Table B-2**
**Alternative 2**
**Land Use Controls (LUCs)**

**Site:** Site 23
**Location:** Naval Station Norfolk, LP-20 Plating Shop
**Phase:** Focused Feasibility Study
**Date:** December 3, 2007

**Description:** Institute Land Use Controls for Limits of Site 23 LP-20 Plating Shop

**CALCULATIONS**

**ASSUMPTIONS**

1) Signage Installation
   * Installation of signs at each of 3 entrance doors and garage entry
   * Signs will meet specifications set forth by the Navy and regulatory agencies
2) Long Term Monitoring
   * Quarterly inspection of site and annual reporting
   * 5 Year review
   * No long term groundwater or soil sampling will be conducted
3) LUCs for 30 year timeframe

**CAPITAL COSTS**

| Description | Qty | Unit | Unit Cost | Total Cost | | Notes |
|---|---|---|---|---|---|---|
| *Preparation of LUC Remedial Design* | 1 | EA | $10,000 | $10,000 | Engineer's Estimate | |
| *Signage* | | | | | | |
| Manufacturing | 4 | EA | $300.00 | $1,200 | Engineer's Estimate | |
| Installation | 4 | EA | $100.00 | $400 | Engineer's Estimate | |
| SUBTOTAL | | | | $1,600 | | |
| **TOTAL CAPITAL COST** | | | | **$11,600** | | |

**OPERATION AND MAINTENANCE COSTS (Years 1-4, 6-9, 11-14, 16-19, 21-24, 26-29)**

| | | | | | |
|---|---|---|---|---|---|
| *Land Use Control Monitoring* | | | | | |
| Quarterly site inspection and annual reporting | 1 | UNIT | $1,200.00 | $1,200 | Engineer's Estimate |
| SUBTOTAL | | | | $1,200 | |
| SUBTOTAL | | | | $1,200 | |
| *Contingency* | 20% | | | $240 | |
| SUBTOTAL | | | | $1,440 | |
| *Project Management* | 6% | | | $86 | |
| **TOTAL ANNUAL OPERATION AND MAINTENANCE COST (Years 1-4, 6-9, 11-14, 16-19, 21-24, 26-29)** | | | | $1,526 | |

**OPERATION AND MAINTENANCE COSTS (Years 5, 10, 15, 20, 25, 30)**

| | | | | | |
|---|---|---|---|---|---|
| *Five Year Reviews* | | | | | |
| Inspection | 1 | UNIT | $1,200.00 | $1,200 | Engineer's Estimate |
| SUBTOTAL | | | | $1,200 | |
| Five year review report | 1 | UNIT | $5,000.00 | $5,000 | Engineer's Estimate |
| SUBTOTAL | | | | | |
| SUBTOTAL | | | | $6,200 | |
| *Contingency* | 20% | | | $1,240 | Engineer's Estimate |
| SUBTOTAL | | | | $7,440 | |
| *Project Management* | 6% | | | $446.40 | |
| **TOTAL ANNUAL OPERATION AND MAINTENANCE COST (Years 5, 10, 15, 20, 25, 30)** | | | | $7,886 | |
| **TOTAL NET PRESENT WORTH (30 Years)** | | | | **$64,998** | |

NOTE: THE ESTIMATE SHOWN ABOVE IS CONSIDERED BUDGETARY-LEVEL COST ESTIMATING, SUITABLE FOR USE IN PROJECT EVALUATION AND PLANNING. ACTUAL CONSTRUCTION COSTS ARE EXPECTED TO VARY FROM THESE ESTIMATES DUE TO MARKET CONDITIONS, ACTUAL COSTS OF PURCHASED MATERIALS, QUANTITY VARIATIONS, REGULATORY REQUIREMENTS, AND OTHER FACTORS EXISTING AT THE TIME OF CONSTRUCTION.

**3.0% Discount Rate**

| Year | | Discount Factor at 3% | Capital Cost | O&M Cost | Total Cost | Total PW Capital Costs at 3% ($) | Total PW O&M Costs at 3% ($) | Total NPV Costs at 3% ($) |
|---|---|---|---|---|---|---|---|---|
| 0 | 2005 | 1.000 | $ 11,600 | | $ 11,600 | $ 11,600 | $ - | $ 11,600 |
| 1 | 2006 | 0.971 | | $ 1,526 | $ 1,526 | $ - | $ 1,482 | $ 1,482 |
| 2 | 2007 | 0.943 | | $ 1,526 | $ 1,526 | $ - | $ 1,439 | $ 1,439 |
| 3 | 2008 | 0.915 | | $ 1,526 | $ 1,526 | $ - | $ 1,397 | $ 1,397 |
| 4 | 2009 | 0.888 | | $ 1,526 | $ 1,526 | $ - | $ 1,356 | $ 1,356 |
| 5 | 2010 | 0.863 | | $ 7,886 | $ 7,886 | $ - | $ 6,803 | $ 6,803 |
| 6 | 2011 | 0.837 | | $ 1,526 | $ 1,526 | $ - | $ 1,278 | $ 1,278 |
| 7 | 2012 | 0.813 | | $ 1,526 | $ 1,526 | $ - | $ 1,241 | $ 1,241 |
| 8 | 2013 | 0.789 | | $ 1,526 | $ 1,526 | $ - | $ 1,205 | $ 1,205 |
| 9 | 2014 | 0.766 | | $ 1,526 | $ 1,526 | $ - | $ 1,170 | $ 1,170 |
| 10 | 2015 | 0.744 | | $ 7,886 | $ 7,886 | $ - | $ 5,868 | $ 5,868 |
| 11 | 2016 | 0.722 | | $ 1,526 | $ 1,526 | $ - | $ 1,103 | $ 1,103 |
| 12 | 2017 | 0.701 | | $ 1,526 | $ 1,526 | $ - | $ 1,071 | $ 1,071 |
| 13 | 2018 | 0.681 | | $ 1,526 | $ 1,526 | $ - | $ 1,039 | $ 1,039 |
| 14 | 2019 | 0.661 | | $ 1,526 | $ 1,526 | $ - | $ 1,009 | $ 1,009 |
| 15 | 2020 | 0.642 | | $ 7,886 | $ 7,886 | $ - | $ 5,062 | $ 5,062 |
| 16 | 2021 | 0.623 | | $ 1,526 | $ 1,526 | $ - | $ 951 | $ 951 |
| 17 | 2022 | 0.605 | | $ 1,526 | $ 1,526 | $ - | $ 923 | $ 923 |
| 18 | 2023 | 0.587 | | $ 1,526 | $ 1,526 | $ - | $ 897 | $ 897 |
| 19 | 2024 | 0.570 | | $ 1,526 | $ 1,526 | $ - | $ 870 | $ 870 |
| 20 | 2025 | 0.554 | | $ 7,886 | $ 7,886 | $ - | $ 4,367 | $ 4,367 |
| 21 | 2026 | 0.538 | | $ 1,526 | $ 1,526 | $ - | $ 821 | $ 821 |
| 22 | 2027 | 0.522 | | $ 1,526 | $ 1,526 | $ - | $ 797 | $ 797 |
| 23 | 2028 | 0.507 | | $ 1,526 | $ 1,526 | $ - | $ 773 | $ 773 |
| 24 | 2029 | 0.492 | | $ 1,526 | $ 1,526 | $ - | $ 751 | $ 751 |
| 25 | 2030 | 0.478 | | $ 7,886 | $ 7,886 | $ - | $ 3,767 | $ 3,767 |
| 26 | 2031 | 0.464 | | $ 1,526 | $ 1,526 | $ - | $ 708 | $ 708 |
| 27 | 2032 | 0.450 | | $ 1,526 | $ 1,526 | $ - | $ 687 | $ 687 |
| 28 | 2033 | 0.437 | | $ 1,526 | $ 1,526 | $ - | $ 667 | $ 667 |
| 29 | 2034 | 0.424 | | $ 1,526 | $ 1,526 | $ - | $ 648 | $ 648 |
| 30 | 2035 | 0.412 | | $ 7,886 | $ 7,886 | $ - | $ 3,249 | $ 3,249 |
| **Total** | **Alternate 2 30 years** | | | | | $ 11,600 | $ 53,398 | **$ 64,998** |

*Discount factor established per "Revisions to OMB Circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis", OSWER Directive No. 9355.3-20, June 25, 1993. Updated January 2007

PW =Present Worth
NPW=Net Present Worth